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USPT	116 and nanofiltration	16	L17
USPT	membrane and koch	1657	L16
USPT	membrane and "TFC-SR1"	0	L15
USPT	112 and polyamide and "TFC" and nanofiltration	4	L14
USPT	112 and polyamide and "TFC-sr1"	0	L13
USPT	210 500 38	566	L12
USPT	110 and positive	3	L11
USPT	17 and charge	5	L10
USPT	17 and koch	0	L9
USPT	17 and "SRI"	0	L8
USPT	TFC and NF and 11	9	L7
USPT	14 and nanofiltration	0	L6
USPT	14 and ananofiltration	0	L5
USPT	"SRI" and 11	20	L4
USPT	"TFC-SR1"	0	L3
USPT	11 and "TFC-SR1"	0	L2
USPT	membrane and polyamide	9855	L1

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**Search History**

Today's Date: 1/3/2002

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**Search Results - Record(s) 1 through 3 of 3 returned****1. Document ID: US 5858240 A**

Jan 12, 1999

List: Entry 1 of 3

File: USPT

US-PAT-NO: 5858240

DOCUMENT-IDENTIFIER: US 5858240 A

TITLE: Nanofiltration of concentrated aqueous salt solutions

DATE-ISSUED: January 12, 1999

## INVENTOR- INFORMATION:

CITY STATE ZIP CODE COUNTRY

## NAME

CAX

Twardowski, Zbigniew

CAX

Sian, Judith G.

Richmond

US-CL-CURRENT 210/652; 210/639, 210/641, 210/651, 210/653, 210/805

Full	Title	Citation	Front	Review	Classification	Date	Reference	Claims	KMC	Draw Desc	Image
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**2. Document ID: US 5587083 A**

Dec 24, 1996

List: Entry 2 of 3

File: USPT

US-PAT-NO: 5587083

DOCUMENT-IDENTIFIER: US 5587083 A

TITLE: Nanofiltration of concentrated aqueous salt solutions

DATE-ISSUED: December 24, 1996

## INVENTOR INFORMATION:

CITY STATE ZIP CODE COUNTRY

## NAME

CAX

Twardowski, Zbigniew

Burnaby

US-CL-CURRENT: 210/652; 210/651, 210/653

Full	Title	Citation	Front	Review	Classification	Date	Reference	Claims	KMC	Draw Desc	Image
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**3. Document ID: US 5147553 A**

Sep 16, 1997

List: Entry 3 of 3

File: USPT

US-PAT-NO: 5147553  
DOCUMENT-IDENTIFIER: US 5147553 A

TITLE: Selectively permeable barriers

DATE-ISSUED: September 15, 1992

INVENTOR- INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Waite, Warren A.	Burlington	MA		

US-CL-CURRENT: 210 654; 210 480; 210 500,34; 427 245

Full	Title	Citation	Front	Review	Classification	Date	Reference	KM/C	Drawn Desc	Image
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Display 10 Documents, starting with Document: 3

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## Generate Collection

Table 1: Entry 1 of 2

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JOURNAL OF CLIMATE

DOCUMENT-IDENTIFIER: US 3,655,624 A  
TITLE: Nanofiltration of concentrated aqueous salt solutions

**ABP1:** Nanofiltration processes using one or more conventional nanofiltration modules under a positive applied pressure is used to selectively change the concentration of one solute, such as sodium chloride or sodium chlorate providing monovalent ions, from another solute such as sodium sulfate or sodium dichromate multivalent ions in high salt aqueous concentrations. The process is particularly useful in favourably lowering the concentration of undesirable ions, particularly, of silica and dichromate ions in chloralkali and chlorate brine containing solutions and favourably raising the sodium sulphate level relative to sodium chloride in chloralkali liquor.

BSFR: This invention relates to a process for reducing the concentration of undesirable compounds, particularly, solutes, in aqueous solutions by nanofiltration using a filtration membrane. More particularly, it relates to the substantial removal of sulfate, dichromate, phosphate, mercury, calcium, magnesium, aluminium, fluoride, and silica monovalent and divalent ions from brine solutions, optionally, containing chloride.

BSPR: Pressure driven membrane separation processes are known wherein organic molecules or inorganic ionic solutes in aqueous solutions are concentrated or separated to various degrees by the application of a positive osmotic pressure to one side of a filtration membrane. Examples of such pressures are reverse osmosis (RO), ultrafiltration (UF) and nanofiltration (NF). These pressure driven membrane processes employ a cross-flow mode of operation wherein only a portion of a feed solution (F) is collected as a permeate solution (P) and the rest is called a pass solution (C). In this specification and claims, the exit process stream from the nanofiltration module, which stream has not passed through the membrane, is referred to as the "pass stream". This stream is often referred to by practitioners in the membrane filtration art as the "concentrate" stream.

BSPR  
Nanofiltration membranes are structurally very similar to reverse osmosis membranes in that chemically, they, typically, are crosslinked aromatic polyamides, which are cast as a thin "skin layer", on top of a microporous polymer sheet support to form a composite membrane structure. The separation properties of the membrane are controlled by the pore size and electrical charge of the "skin layer". Such a membrane structure is usually referred to as a thin film composite (TFC). However, unlike RO membranes, the NF membranes are characterized in having a larger pore size in its "skin layer" and a net negative electrical charge inside the individual pores. This negative charge is responsible for rejection of anionic species, according to the anion surface charge density. Accordingly, divalent anions, such as SO<sub>4</sub><sup>2-</sup>, are more strongly rejected than monovalent ones, such as Cl<sup>-</sup>. Commercial NF membranes are available from known suppliers of RO and other pressure drive membranes. Examples include: Desal-5 membrane (Desalination Systems, Escondido, Calif.), NF50, NF40 and NF40HF membranes FilmTec Corp., Minneapolis, Minn., NF-1, NF2, NF3, NF40 and NF40HF membranes Nippon Soda Co., Japan, and NTR 7450 and NTR 7250 membranes Nippon Electric Glass Co., Japan. The NF membranes are, typically, packaged as membrane modules. A so-called "spiral wound" module is most popular, but other membrane module configurations, such as tubular membranes enclosed in a shell or plate and-frame, are also known.

## BSPR:

Nanofiltration membranes have been reported to show no or little rejection of low molecular weight organic molecules, such as, methanol, ethanol and ethyleneglycol, but a significant rejection of higher molecular weight organic species, such as glucose. Among inorganic ionic solutes, low to fairly high rejection has been reported for simple 1:1 electrolytes, such as NaCl or Na<sub>2</sub>SO<sub>4</sub>, and high rejection of other electrolytes where multivalent ionic species are involved, such as Na<sub>2</sub>SO<sub>4</sub>, MgCl<sub>2</sub> and FeCl<sub>3</sub>, such a characteristic differentiates NF from RO which rejects all ionic species, and from ultrafiltration (UF), which does not reject ionic species and only rejects organic compounds with molecular weights, typically, in excess of 1,000 daltons.

## BSIR:

During the NF process, a minimum pressure equal to the osmotic pressure difference between the feed pass liquor on one side and the permeate liquor on the other side of the membrane must be applied since osmotic pressure is a function of the ionic strengths of the two streams. In the case of separation of a multivalent solute, such as Na<sub>2</sub>SO<sub>4</sub>, from a monovalent one, such as NaCl, the osmotic pressure difference is moderated by the low NaCl rejection. Usually, a pressure in excess of the osmotic pressure difference is employed to achieve practical permeate flux. In view of lower NaCl rejection, NF has been used successfully for removal of sulfate and the hardness cations, Ca<sup>2+</sup> and Mg<sup>2+</sup> from brackish waters and even seawater, without the necessity to excessively pressurize the feed stream. The reported typical pressure range for NF is 80 to 300 psi, although membrane elements are designed to withstand pressures of up to 1,000 psi.

## BSPR:

Reported uses of NF include the aforesaid water softening, removal of dissolved multivalent ions such as Ba<sup>2+</sup>, reduction of silica as a part of feedwater conditioning for a subsequent RO step or removal of medium of medium molecular weight organic compounds. It has also been demonstrated that high rejection of ionic species could be obtained by proper conditioning of the stream, i.e. by changing its pH. This, effective removal/rejection of carbonate anion could be achieved by adjusting the pH of the feed solution to about 12, to ensure that carbonate would predominantly exist as CO<sub>3</sub><sup>2-</sup>, which anion is more strongly rejected by the NF membrane than the HCO<sub>3</sub><sup>-</sup> anion.

## BSPR:

Dissolved or suspended silica in brine feed for chloralkali processes, especially the so-called membrane chloralkali process, presents a problem in that the silica forms scale on the surface or in the interior of the ion exchange membrane separator. This causes the cell voltage and, hence, power consumption to increase. In general, in the membrane chloralkali process, the concentration of silica in the feed brine should not exceed 10 ppm, although even a lower level may be needed if some other contaminants, such as Al<sup>3+</sup>, are present, since these contaminants enhance the scaling capacity of silica.

## BSPR:

Use of strongly basic anion exchange membranes for silica removal from feedwater has been reported. However, the literature also recognizes that, in that case since there is a substantial background of other salts, the selectivity of the IX resin towards silica is greatly reduced.

## BSPR:

Recent literature from FilmTec Corp., Minneapolis, Minn., describes the removal of silica from feedwater with a NF70 nanofiltration membrane as part of a pretreatment for a subsequent RO step. A reduction of silica concentration in feedwater from 400 ppm to 50-60 ppm has been mentioned. The literature is silent, however, on the use of NF methods for silica removal from higher concentration salt solutions, such as chloralkali brine.

## BSPR:

In a related chemical process, chlorine and caustic soda are prepared in an electrolytic cell, which contains a membrane to prevent chlorine and caustic from reacting and the separated chemicals are removed.

## BSIR:

Sulfate ion is a common ingredient in commercial salts. When such salt is added directly, or in the form of a brine solution, and specific steps are not taken to remove the sulfate, the sulfate enters the electrolytic system. Sulfate ion maintains its identity under the conditions in the electrolytic system and, thus, accumulates and progressively increases in concentration in the system until removed in some manner. In chlorate plants producing a liquor product, the sulfate ion will leave with the product liquor. In plants producing only crystalline chlorate, the sulfate remains in the mother liquor after the crystallization of the chlorate, and is recycled to the cells. Over time, the concentration of sulfate ion will increase and adversely affect electrolysis and cause operational problems due to localized precipitation in the electrolytic cells. Within the chloralkali circuit, the sodium sulfate will concentrate and adversely affect the membrane, which divides the anolyte brine from the catholyte caustic soda.

BSIR:

Accordingly, in its broadest aspect the invention provides in a nanofiltration process for filtering an aqueous liquor comprising feeding a feed liquor to a nanofiltration membrane module under a positive pressure to provide a pass liquor and a permeate liquor for selectively changing the concentration of a first compound relative to the concentration of a second compound in said aqueous compound wherein said first compound has a first feed concentration and said second liquor wherein said first compound has a second feed concentration, said process comprising feeding said aqueous liquor to said nanofiltration membrane module, collecting said pass liquor wherein said first compound is at a first pass concentration and said second compound is at a second pass concentration, and collecting said permeate liquor wherein said first compound has a first permeate concentration and said second compound is at a second permeate concentration, the improvement comprising said first compound having a first concentration of greater than 50 g/l.

BSPR:

We have discovered that, for example, subjecting a concentrated sodium chloride-sodium sulfate solution to the NF process results in a very strong positive rejection of sodium sulfate by the membrane, but only a weak positive or negative rejection of the sodium chloride. Surprisingly, we have found that with increasing concentration of sodium sulfate in the feed liquor, the rejection of sodium chloride decreases and eventually becomes negative. However, sodium chloride rejection need not be negative in that the NaCl concentration in the permeate may be slightly lower than that in the feed. The pronounced influence of Na<sub>2</sub>SO<sub>4</sub> concentration in the feed on NaCl rejection values is most surprising

BSPR:

Thus, surprisingly we have found that nanofiltration membrane processes can be used to beneficially reduce the concentration of multivalent ions, such as SO<sub>4</sub><sup>2-</sup>, CrO<sub>4</sub><sup>2-</sup> or Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> and dissolved silica in concentrated solutions of sodium chloride, such as brine, and concentrated sodium chlorate process liquors, wherein the main components are sodium chlorate and sodium chloride.

BSPR:

We have most surprisingly found, notwithstanding the teachings that commercially available nanofiltration membranes have a monocharged anion rejection property, e.g. a Cl<sup>-</sup> ion rejection in the range 20-50%, that such membranes when used with concentrated salt solutions exhibit no Cl<sup>-</sup> ion rejection. This unexpected absence of chloride rejection by the nanofiltration membrane has a significant practical importance in minimizing the osmotic pressure across the membrane and hence the energy required for pressuring the feed to achieve a g/l permeate flow. Further, in surprising contrast, the rejection of multivalent ions such as SO<sub>4</sub><sup>2-</sup>, CrO<sub>4</sub><sup>2-</sup> or Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> and, also, silica, remains high.

BSIR:

Accordingly, such unexpected ion membrane selectivity at relatively high salt concentrations offers attractive applications such as, for example, in the treatment of chloralkali brine liquors having sodium sulfate levels unacceptable in recycle systems. As illustrated in an application of sulfate removal from brine, because there is no buildup in concentration of sodium chloride in the pass liquor stream over its original level in the feed stream, it is possible to

increase the content of sodium sulfate in the pass liquor to a slight level that would have been possible if the NaCl level of the pass liquor was increased. Accordingly, it is now possible to realize a relatively high % Recovery, and in the case of the alkali brine, to minimize the volume of brine passed and reduce the size of a reactor and the amount of chemicals for an optional, downstream sulfate precipitation step.

**BSIR:**

The processes of the invention are applicable as either single stage batch processes with optional recycle of either pass liquor or permeate liquor to the nanofiltration membrane module, or as part of a multi-stage, multi-module system.

**BSIR:**

The process of the invention as hereinabove defined may be operated at any suitable and desired temperature selected from 0-degree C. to the melting point of the feed liquor; and positive pressures applied to the feed side, generally selected from 50-1200 psi.

**BSPV**

(a) Desal-5 Membrane Product Application Note, publication of Desalination Systems, Inc. (Escondido, Calif.), April 1991, wherein the Figure on page E-19.3 shows NaCl rejection in the 55 to 85% range.

**BSPV:**

(b) NT75 Membrane, Product Specification, publication of Filmtec Corp., Minneapolis, Minn., cites Rejection of 60%; and

**BSPV:**

(c) "Membrane Handbook", ed. By W. S. W. Ho and K. K. Sirkar, Van Nostrand Reinhold, N.Y. 1992 at Table 23.2. "Characteristics of Selected Nanofiltration Membranes", cites NaCl % Rejection of: 80% for NF50 membrane (Filmtec), 45% for NF40 membrane (Filmtec), 50% for NTF-7250 membrane (Nitto), 47% for Desal-5 NF40 membrane (Desalination Systems), and 55% for SU200HF membrane (Toray).

**DRPR:**

FIG. 1 represents a diagrammatic flow sheet of a single stage membrane nanofiltration system of use in a process according to the invention; and

**DRPR:**

FIG. 2 represents a diagrammatic flow sheet of a multistage membrane nanofiltration system of use in a process according to the invention.

**DEPR:**

FIG. 1 shows generally as 10, a single stage membrane nanofiltration system for the separation of, for example, solute A from solute B in an aqueous liquor. System 10 comprises a feed solution holding tank 12 connected to a nanofiltration membrane module 14 by a feed conduit 16 through a high pressure pump 18 (Model T-2401, CID Pumps Inc.). Module 15 comprises a single spiral wound type nanofiltration module containing Desal-5, DL2540 polyamide membrane 20 having 2.5 m.sup.2 of active membrane area. Exiting module 14 is a pass liquor conduit 22 having a pressure control valve 24 and a permeate liquor conduit 26.

**DEPR:**

The process depicted in FIG. 1 represents a single stage or batch-type process, wherein the pass liquor or the permeate liquor may be of sufficient and desired quality for use in a subsequent process or discharge. However, each of the pass and permeate streams, optionally, individually, may be sent through a nanofiltration membrane process again, in one or more cycles, in either a batch or continuous process. In industrial processes of use in the practise of the invention, the pass stream from the first stage may be sent to the second stage to increase the overall % Recovery. Alternatively, the NF process may be conducted in a batch mode with the pass liquor recycled back to the feed tank. Accordingly, in consequence, the feed composition will vary with time as will the Membrane Flux and possibly the % Rejection.

**DEPR:**

FIG. 2 represents a multi-stage NF method for the purification of brine by removal of sodium sulfate, according to the invention, wherein a plurality of NF

reciprocating filter according to the invention, mix in the pass liquor in which numbered 14A-14F, consecutively, are connected in series. Feed liquor is fed under pressure by high pressure pump 5, to module 14A. Pass liquors 11-15 are passed to subsequent adjacent modules, while the permeate liquors 1a-1f may be combined into a single resultant purified brine stream. The final pass liquor may be discharged to sewer.

**DEPR:**

The following Examples illustrate specific compounds used in the process as described by FIG. 1 wherein data was collected using an experimental NF filter 10 which consisted of a single NF membrane filter element, 2.5" diameter, 4" long, containing Desal-2 CL2541 membrane from Desalination Systems, Inc., Encino, Calif. The active membrane area was 2.5 m<sup>2</sup>. All runs were conducted at temperature 45.degree.-51.degree. C.

**DEPR:**

A batch of 8. liters of brine solution containing 1.6 gpi NaCl and 0.4 gpi Na<sub>2</sub>SO<sub>4</sub> at a temperature of 51.degree. C. was added to tank 12. High pressure pump 18 was turned on and the pressure on the feed side was adjusted to 400.+-5 psi and kept constant during the run. Both permeate and pass liquor streams were collected into separate tanks over a period of 11.5 minutes. Both streams were approximately constant during the permeate and the pass liquor flow rates were approximately constant during the run at about 2.0 lpm and 3.3 lpm, respectively. Following the run, 25 l of permeate with a composition of 190.1 gpi NaCl and 0.25 gpi Na<sub>2</sub>SO<sub>4</sub> and 34 l of concentrate with a composition of 190.7 gpi NaCl and 16.3 gpi Na<sub>2</sub>SO<sub>4</sub> were collected while 20 l of the feed brine remained in the feed tank. Calculated NF membrane % Rejections are: 97.3% for Na<sub>2</sub>SO<sub>4</sub> and 1.1% for NaCl.

**DEPR:**

A similar process was carried out under the same conditions as for Example 1, wherein the volume of feed brine was 76 liters containing 195.9 gpi NaCl and 16.7 gpi Na<sub>2</sub>SO<sub>4</sub>. After 16 minutes of operation with a feed pass pressure maintained at 400.+-5 psi, 18 l of permeate and 38 l of concentrate were collected while 19 l of the feed brine remained in the feed tank. The composition of the permeate was 194.7 gpi NaCl and 0.37 gpi Na<sub>2</sub>SO<sub>4</sub>. The composition of concentrate was 192.8 gpi NaCl and 26.3 gpi Na<sub>2</sub>SO<sub>4</sub>. Calculated NF membrane % Rejections are: 97.9% for Na<sub>2</sub>SO<sub>4</sub> and 1.5% for NaCl.

**DEPR:**

In this example a recycle batch mode of operation was carried out wherein the pass stream was recycled back to the brine feed tank. A starting volume of feed brine was 76 l having a composition of 197.5 gpi NaCl and 16.7 gpi Na<sub>2</sub>SO<sub>4</sub>. The flow rate of permeate was kept constant at 1.3 lpm. The resulting feed pass pressure was initially at 295 psi and at the end of the process at 715 psi. After 45.5 minutes 30 l of permeate were collected while the volume in the feed tank decreased to 26 l. The composition of permeate was 200.4 gpi NaCl and 0.38 gpi Na<sub>2</sub>SO<sub>4</sub>. The composition of brine solution remaining in the feed tank was 188.4 gpi NaCl and 44.8 gpi Na<sub>2</sub>SO<sub>4</sub>. The calculated NF membrane % Rejections were 97.7% for Na<sub>2</sub>SO<sub>4</sub> and -1.5% for NaCl.

**DEPR:**

A recycle batch process similar to that of Example 3 was carried out with a liquor further containing silica and having a pH of 10.7. The initial volume of brine feed solution was 75 l and had a composition of 248.8 gpi NaCl, 30.1 gpi Na<sub>2</sub>SO<sub>4</sub> and 9.1 ppm SiO<sub>2</sub>. The feed pass liquor pressure was kept constant at 320.+-5 psi. After 64 minutes 57 l of permeate was collected while the volume of solution in the feed tank decreased to 24 l. The composition of the volume of solution in the feed tank was 257.5 gpi NaCl, 3.85 gpi Na<sub>2</sub>SO<sub>4</sub> and 5.6 ppm SiO<sub>2</sub>. The composition of brine solution remaining in the feed tank was 24.8 gpi NaCl, 79.8 gpi Na<sub>2</sub>SO<sub>4</sub> and 15.1 ppm SiO<sub>2</sub>. The calculated NF membrane % Rejections were 97.2% for Na<sub>2</sub>SO<sub>4</sub>, 4.9% for NaCl and 39.8% for SiO<sub>2</sub>.

**DEPR:**

A batch of 75 l of chloride liquor feed solution containing 395 gpi NaClO<sub>4</sub>, 1.11 gpi NaCl, 20.8 gpi Na<sub>2</sub>SO<sub>4</sub>, 5.1 gpi Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and a pH of 7 and a temperature of 45.degree. C. was added to tank 12. The high

pressure on the feed side was maintained at 44.1 psi and kept constant during the run. Feed pressure and feed liquor streams were collected and sampled during the run. In total, 20.1 liters of permeate liquor and 1.1 liters of liquor were collected, while 18.1 liters of feed solution remained in the tank. The feed flows were 1.22 lpm and 1.11 lpm, respectively. Subsequent chemical analysis revealed that the permeate liquor had 3.8 gpl NaCl<sub>0.5</sub>sub.3, 1.11 gpl NaCl<sub>4.1</sub> sub.3, 0.1 gpl Na<sub>2</sub>SO<sub>4</sub> sub.4, and 2.1 gpl Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> sub.7, while the feed stream had 3.8 gpl NaCl<sub>0.5</sub>sub.3, 9.6 gpl NaCl, 4.11 gpl Na<sub>2</sub>SO<sub>4</sub> sub.4 and 0.1 gpl Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> sub.7. Calculated NF membrane % Rejections were: -99.8% for NaCl, -0.7% for NaCl<sub>0.5</sub>sub.3, 91.9% for Na<sub>2</sub>SO<sub>4</sub> sub.4 and 4.9% for Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> sub.7.

**DEPR:**  
The following examples 4-8 further demonstrate the range of NaCl rejections during NF membrane treatment of NaCl--Na<sub>2</sub>SO<sub>4</sub> SC sub.4 solutions.

**DEPR:**  
A batch of 80 liters of feed brine solution composed of 169.2 g/l NaCl and 11.1 g/l of Na<sub>2</sub>SO<sub>4</sub> sub.4 was passed to the NF rig. Under an applied pressure of 283 psi, 10 liters of permeate liquor were collected, which represents 12.5% recovery. The permeate had a composition of 177.9 g/l NaCl and 0.15 g/l Na<sub>2</sub>SO<sub>4</sub> sub.4. The calculated rejections were: 6.7% for NaCl and 99.6% for Na<sub>2</sub>SO<sub>4</sub> sub.4, respectively.

**DEPR:**  
A batch of 80 liters of feed brine solution composed of 184.2 g/l NaCl and 11.1 g/l of Na<sub>2</sub>SO<sub>4</sub> sub.4 was passed to the NF rig. Under an applied pressure of 302 psi, 28 liters of permeate liquor were collected, which represents 35% recovery. The permeate had a composition of 188.7 g/l NaCl and 0.2 g/l Na<sub>2</sub>SO<sub>4</sub> sub.4. The calculated rejections were: 3.4% for NaCl and 98.3% for Na<sub>2</sub>SO<sub>4</sub> sub.4, respectively.

**DEPR:**  
A batch of 80 liters of feed brine solution composed of 179 g/l NaCl and 71.3 g/l of Na<sub>2</sub>SO<sub>4</sub> sub.4 was passed to the NF rig. Under an applied pressure of 545 psi, 9 liters of permeate liquor were collected, which represents 11.3% recovery. The permeate had a composition of 196.0 g/l NaCl and 0.9 g/l Na<sub>2</sub>SO<sub>4</sub> sub.4. The calculated rejections were: 8.7% for NaCl and 98.8% for Na<sub>2</sub>SO<sub>4</sub> sub.4, respectively.

**DEPR:**  
A batch of 80 liters of feed brine solution composed of 9.9 g/l NaCl and 87.5 g/l of Na<sub>2</sub>SO<sub>4</sub> sub.4 was passed to the NF rig. Under an applied pressure of 516 psi, 9.6 liters of permeate liquor were collected, which represents 12% recovery. The permeate had a composition of 18.4 g/l NaCl and 2.4 g/l Na<sub>2</sub>SO<sub>4</sub> sub.4. The calculated rejections were: -84.6% for NaCl and 97.0% for Na<sub>2</sub>SO<sub>4</sub> sub.4, respectively.

**DEPR:**  
A batch of 80 liters of feed brine solution having a NaCl concentration of 286.7 g/l, pH 3, and spiked with 2.9 ppm F<sup>sup.-</sup> was passed to the NF rig. Under an applied pressure of 501 psi, 8.6 liters of permeate liquor were collected, which represents 10.7% recovery. The permeate had a composition of 281 g/l NaCl and 2.0 ppm F<sup>sup.-</sup>. The calculated rejections were: 2.5% for NaCl and 10.3% for F<sup>sup.-</sup>, respectively.

**DEPR:**  
A batch of 80 liters of feed brine solution having a NaCl concentration of 286.7 g/l, pH 3, spiked with 3.2 ppm F<sup>sup.-</sup> and 1.5 ppm Fe<sup>sup.+2</sup>, was passed to the NF rig. Under an applied pressure of 548 psi, 8.8 liters of permeate liquor were collected, which represents 11% recovery. The permeate had a composition of 281 g/l NaCl and 2.5 ppm F<sup>sup.-</sup>. The calculated rejections were: 2.2% for NaCl and 21.5% for F<sup>sup.-</sup>, respectively.

**DEPR:**  
A batch of 80 liters of feed brine solution having a NaCl concentration of 286.7 g/l, pH 3, spiked with 3.1 ppm F<sup>sup.-</sup> and 1.5 ppm Fe<sup>sup.+2</sup>, was fed to the NF rig. Under an applied pressure of 557 psi, 8.8 liters of permeate liquor were collected, which represents 11% recovery. The permeate had a composition of 281 g/l NaCl and 2.5 ppm F<sup>sup.-</sup>. The calculated rejections were: 2.2% for NaCl and 21.5% for F<sup>sup.-</sup>, respectively.

collected which represents 100% recovery. The permeate contained 4.1 g/l NaCl and 1.1 ppm Fluoride. The calculated rejections were 99.9% for NaCl and 99.8% for Fluoride, respectively.

#### DEIR:

A batch of 4.0 liters of feed sulphate brine solution containing 4.0 g/l NaCl and 1.0 g/l NaCl at a pH of 7.0 was passed to the NF rig. Under an applied pressure of 575 psi, 1.8 liters of permeate liquor were collected, which represents 50% recovery. The permeate contained 1.0 g/l NaCl and 0.1 ppm Fluoride. The calculated rejections were 97.0% for NaCl and 99.9% for NaCl, respectively.

#### DEIR:

A batch of 4.0 liters of feed sulphate brine solution containing 4.0 g/l NaCl and 1.0 g/l NaCl at a pH of 7.0 was passed to the NF rig. Under an applied pressure of 575 psi, 1.4 liters of permeate liquor were collected, which represents 35% recovery. The permeate contained 4.0 g/l NaCl and 0.1 ppm Fluoride. The calculated rejections were 97.0% for NaCl and 99.9% for NaCl, respectively.

#### DEPR:

This example demonstrates the efficacy of the NF method for removal of Al.sup.3+ from brine.

#### DEPR:

A batch of 80 liters of feed brine solution containing 248.2 g/l NaCl and 1.0 ppm Al.sup.3+ was passed to the NF rig. Under an applied pressure of 460 psi, 27.5 liters of permeate liquor were collected, which represents 35% recovery. The permeate contained 245.7 g/l NaCl and about 1 ppm Al.sup.3+. The calculated rejections were: 1.4% for NaCl and 90.5% for Al.sup.3+, respectively.

#### DEPR:

This example demonstrates the efficacy of the NF process for the removal of mercury from brine.

#### DEPR:

A batch of 80 liters of feed brine containing 248.2 g/l NaCl and 1.0 ppm Hg.sup.++ was passed to the NF rig. Under an applied pressure of 460 psi, 28.5 liters of permeate liquor were collected, which represents 35.6% recovery. The permeate contained 244.6 g/l NaCl and 7.1 ppm Hg.sup.++. The calculated rejections were: 1.8% for NaCl and 2% for Hg.sup.++, respectively.

#### DEPR:

Examples 17-21 demonstrate the efficacy of the NF method for the removal of Ca.sup.++ and Mg.sup.++ from brine and the effect of pH and brine strength thereon.

#### DEPR:

A batch of 80 liters of feed brine containing 288.7 g/l NaCl and 1.0 ppm Ca.sup.++ at a pH of 7.8 was passed to the NF rig. Under an applied pressure of 295 psi, 9.5 liters of permeate liquor were collected, which represents 11.6% recovery. The permeate contained 282.5 g/l NaCl and 87.5 ppm Ca.sup.++. The calculated rejections were: 2.3% for NaCl and 12.5% for Ca.sup.++, respectively.

#### DEIR:

A batch of 80 liters of feed brine containing 311.5 g/l NaCl and 1.0 ppm Ca.sup.++ at a pH of 7.0 was passed to the NF rig. Under an applied pressure of 295 psi, 10.4 liters of permeate liquor were collected, which represents 11.6% recovery. The permeate contained 295 g/l NaCl and 1.0 ppm Ca.sup.++. The calculated rejections were: 2.2% for NaCl and 28% for Ca.sup.++, respectively.

#### DEIR:

A batch of 80 liters of feed brine containing 189.4 g/l NaCl and 7.1 g/l Ca.sup.++ at a pH of 7.0 was passed to the NF rig. Under an applied pressure of 295 psi, 10.4 liters of permeate liquor were collected, which represents 11.6% recovery. The permeate contained 173.1 g/l NaCl and 7.1 g/l Ca. The calculated rejections were: 4.4% for NaCl and 50.0% for Ca, respectively.

#### DEPR:

A batch of 4 liters of feed brine containing 235 g/l KCl and 14 g/l KSCN, passed an nanofiltration rig at 100 psi, was passed to the NF rig. Under an applied pressure of 120 psi, 11.9 liters of permeate liquor was collected, which represents 17.8% recovery. The permeate contained 217.5 g/l KCl and 1.6 g/l K<sub>2</sub>SCN. The calculated rejections were: 91.9% for KCl and 95.2% for K<sub>2</sub>SCN, respectively.

**DEIR:**

Examples 21 and 22 demonstrate the efficacy of the NF treatment when it is used in the separation of K<sub>2</sub>SCN from KCl and KBr brines.

**DEIR:**

A batch of 4 liters of feed brine containing 235 g/l KCl and 14 g/l KSCN was passed to the NF rig. Under an applied pressure of 120 psi, 11.9 liters of permeate liquor were collected, which represents 17.8% recovery. The permeate contained 217.5 g/l KCl and 1.6 g/l K<sub>2</sub>SCN. The calculated rejections were: 91.9% for KCl and 95.2% for K<sub>2</sub>SCN, respectively.

**DEIR:**

A batch of 40 liters of feed brine containing 235 g/l KBr and 14 g/l K<sub>2</sub>SCN was passed to an NF rig. Under an applied pressure of 120 psi, 11.9 liters of permeate liquor were collected, which represents 17.8% recovery. The permeate contained 242.4 g/l KBr and 1.4 g/l K<sub>2</sub>SCN. The calculated rejections were: 4.2% for KBr and 97.1% for K<sub>2</sub>SCN, respectively.

**CLPR:**

1. In a nanofiltration process for filtering liquor comprising feeding feed liquor to a nanofiltration membrane module under a positive applied pressure to provide a pass liquor and a permeate liquor for selectively changing the concentration of a first compound relative to the concentration of a second compound in said aqueous liquor, wherein said first compound has a first feed concentration and said second compound has a second feed concentration, the process comprising feeding said aqueous liquor to said nanofiltration membrane module, collecting said pass liquor wherein said first compound is at a first pass concentration and said second compound is at a second pass concentration, and collecting said permeate liquor wherein said first compound has a first permeate concentration and said second compound is at a second permeate concentration, the improvement comprising said first compound having a first feed concentration of greater than 50 g/L; the ratio of the first feed compound concentration to the second feed compound concentration in the permeate liquor increases and in the pass liquor decreases relative to their ratio in the feed liquor; and wherein said first feed compound contains monovalent ions and said second feed compound contains divalent trivalent ions.

**CLPR:**

2. A process as defined in claim 1 further comprising feeding said pass liquor to one or more nanofiltration membrane modules connected in series so as to produce a second pass liquor and subsequent pass liquors, consecutively.

**CLPR:**

3. A process as defined in claim 1 further comprising feeding said permeate liquor to one or more nanofiltration membrane modules connected in series so as to produce a second permeate liquor and subsequent permeate liquors, consecutively.

**CLPR:**

4. A process as defined in any one of claims 1, 10 or 11, wherein said pass liquor or said permeate liquor is recycled back to one or more of said nanofiltration membrane modules.

**CLIL:**

Desalination System, Inc. Escondido, CA, Apr. 1981, "Desal-t Membrane Product Application Note".

**CEIR:**

"Membrane Handbook", Ed. by W.S.W. Ho and M.M. Sikker, Van Nostrand Reinhold, New York, 1981.

**WEST** Generate Collection

114: Entry 1 of 4

File: USPT

Dec 2, 1997

US-PAT-NO: 5600227  
DOCUMENT-IDENTIFIER: US 5600227 A

TITLE: Catalyst mediated method of interfacial polymerization on a micro-porous support, and polymers, fibers, films and membranes made by such method

DATE-ISSUED: December 2, 1997

## INVENTOR- INFORMATION

NAME	CITY	STATE	ZIP CODE	COUNTRY
Costa, Lawrence S.	Mansfield	MA		

## ASSIGNEE- INFORMATION

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Ionics, Incorporated	Watertown	MA			82

APPL-NO: 4 341496

DATE FILED: November 17, 1994

INT-CL: [6] B61D 61/00, B61D 67/00

US-CL-ISSUED: 210/650, 210/490, 210/500.38, 96/14, 95/45, 427/245

US-CL-CURRENT: 210/650; 210/490, 210/500.38, 427/245, 95/45, 96/14

FIELD-OF-SEARCH: 427/245, 427/246, 210/490, 210/500.37, 210/500.38, 210/500.41, 210/650, 210/651, 96/14, 264/45.1, 95/45

## PRIOR-ART-DISCLOSED:

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 Search Selected  Search ALL

PAT-N	ISSUE DATE	PATENTEE NAME	REF ID
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4259143	March 1981	Fadette	210-434
4207344	July 1981	Fadette	210-434
4286155	August 1981	Jacquiss et al.	210-434
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4317343	August 1981	Rak et al.	427-244
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4643829	February 1987	Sundet	210-513
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4763346	November 1988	Sundet	427-244
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5019264	May 1991	Arthur	210-513
5051178	September 1991	Nemura et al.	210-513
5084182	January 1992	Arthur	210-434
5085777	February 1992	Arthur	210-513
5152301	October 1992	Hodgdon	210-434
5234598	August 1993	Tran et al.	210-434
5246587	September 1993	Tomaschke	210-434

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FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US CL
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2144484A1	July 1981	DEX	
3848822A1	January 1985	DEY	
281337	August 1990	DEX	
2152521	December 1991	JPX	
4356537	November 1992	CPX	
WO 92 13665	November 1992	WON	

McGregor, S., Bendix Research, Inc., "The Mechanics of Human Attitudes", in *Human Resource Management: Methodology, Theory, and Practice*, Vol. 1, No. 1, 1969.

The Handbook of Industrial Membrane Technology, M. L. Porter, Ed., Marcel Dekker, 1992.

Hutley, G. et al., *Angew. Chem. Int. Ed. Engl.* 17, 1978, at 100-101.

Silveren, E., *Chemical Society Reviews*, Vol. 1, No. 2, 1993.

"4-Dialkylaminopyridines: Super Asylation Catalysts" at 124-125.

ART-UNIT: 120

PRIMARY-EXAMINER: Dodge, Joseph W

ATTY-AGENT-FIRM: Lappin & Klemmer LLP

ABSTRACT:

The invention pertains to the polymerization of monomers having polar and nucleophilic constituents in the same or different molecules, with polymerization being initiated by aminopyridine catalysts which are substantially regenerated during polymerization. The invention also pertains to polymer products of such polymerization, to permselective membranes containing such polymers, and to processes and apparatus for separating fluids.

45 Claims, 2 Drawing figures

**WEST** Generate Collection**Search Results - Record(s) 11 through 16 of 16 returned****11 Document ID: US 6001889 A**

List: Entry 11 of 16

File: USPT

Dec 14, 1999

US-PAT-NO: 6,001,889

DOCUMENT-IDENTIFIER: US 60 1889 A

TITLE: Polymers with fractal structure

DATE-ISSUED: December 14, 1999

## INVENTOR-INFO:

NAME	CITY	STATE	ZIP CODE	COUNTRY
LeFebvre, Michel S. M.	Kurrajong Heights			AUX

US-CL-CURRENT: 521/82 Full  Title  Citation  Front  Review  Classification  Date  Reference KMC  Draw Desc  Image**12 Document ID: US 5968585 A**

List: Entry 12 of 16

File: USPT

Oct 19, 1999

US-PAT-NO: 5968585

DOCUMENT-IDENTIFIER: US 5968585 A

TITLE: Process for recovery of protein from aqueous media in corn wet milling

DATE-ISSUED: October 19, 1999

## INVENTOR-INFO:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Liaw, Gin C.	Decatur	IL		
Cheryan, Munir	Urbana	IL		

US-CL-CURRENT: 426/636, 210/641, 210/650, 210/651, 210/653, 426/478, 426/482,  
426/629, 530/376, 530/377, 530/414 Full  Title  Citation  Front  Review  Classification  Date  Reference KMC  Draw Desc  Image**13 Document ID: US 5773076 A**

List: Entry 13 of 16

File: USPT

Jul 21, 1998

US-PAT-NO: 5616595

DOCUMENT-IDENTIFIER: US 5616595 A

TITLE: Process for recovery of insoluble protein from stamp water

DATE-ISSUED: June 30, 1994

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Blawie, Bill C.	Decatur	IL		
Leitz, Eric H.	Decatur	IL		
Sherryan, Muniz	Urbana	IL		

US-CL-CURRENT: 426 656; 210 641, 211 651, 210-651, 210 653, 426 428, 426 430, 426 629, 521 376, 521 414

[Full](#) [Title](#) [Citation](#) [Front](#) [Review](#) [Classification](#) [Date](#) [Reference](#)[KMC](#) [Draw Desc](#) [Image](#)

## 14. Document ID: US 5616595 A

L17: Entry 14 of 16

File: USPT

Apr 1, 1997

US-PAT-NO 5616595

DOCUMENT-IDENTIFIER: US 5616595 A

TITLE: Process for recovering water insoluble compounds from a fermentation medium

DATE-ISSUED: April 1, 1997

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Chu, Alexander H. T.	Buffalo Grove	IL		
Wloch, Gene P.	Lake Villa	IL		

US-CL-CURRENT: 514 244

[Full](#) [Title](#) [Citation](#) [Front](#) [Review](#) [Classification](#) [Date](#) [Reference](#)[KMC](#) [Draw Desc](#) [Image](#)

## 15. Document ID: US 5279739 A

L17: Entry 15 of 16

File: USPT

Jan 18, 1994

US-PAT-NO 5279739

DOCUMENT-IDENTIFIER: US 5279739 A

TITLE: Durable filtration membrane having optimized molecular weight

DATE-ISSUED: January 18, 1994

## INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Pemawansa, K. P.	Bradford	MA		

US-CL-CURRENT: 210 511-517; 211 511, 512, 211 512, 211 513, 426 428, 426 430

<a href="#">Full</a>	<a href="#">Title</a>	<a href="#">Citation</a>	<a href="#">Front</a>	<a href="#">Review</a>	<a href="#">Classification</a>	<a href="#">Date</a>	<a href="#">Reference</a>	<a href="#">KMC</a>	<a href="#">Draw Desc</a>	<a href="#">Image</a>
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16 Document ID US 5147541 A

INFO: Entry is at 16

File: USPTO

Step 15, 1991

US-PAT-NO: 5147541

DOCUMENT-IDENTIFIER: US 5147541 A

TITLE: Spiral filtration module with suspended ~~polymer~~ ~~membrane~~ addition and filter ~~construction~~

DATE ISSUED: September 16, 1992

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
McDermott, Jr., Thomas C.	Lynn	MA		
Skelton, Daniel F.	Billerica	MA		

US-CL-CURRENT: 210 321.74; 156 290, 210 321.61, 210 423.4, 423 157, 423 158, 423 173

<a href="#">Full</a>	<a href="#">Title</a>	<a href="#">Citation</a>	<a href="#">Front</a>	<a href="#">Review</a>	<a href="#">Classification</a>	<a href="#">Date</a>	<a href="#">Reference</a>	<a href="#">KMC</a>	<a href="#">Draw Desc</a>	<a href="#">Image</a>
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